BAY AREA
AIR QUALITY
MANAGEMENT
DISTRICT

Transportation Demand Management Tool

User's Guide

BAAQMD
939 Ellis Street
San Francisco, CA 94109
David Vintze, Planning Manager
Ian Peterson, Environmental Planner

Prepared by:
Fehr and Peers
Jerry Walters, Principal
Meghan Mitman, Project Manager
Tien-Tien Chan, Lead Author and Tool Developer
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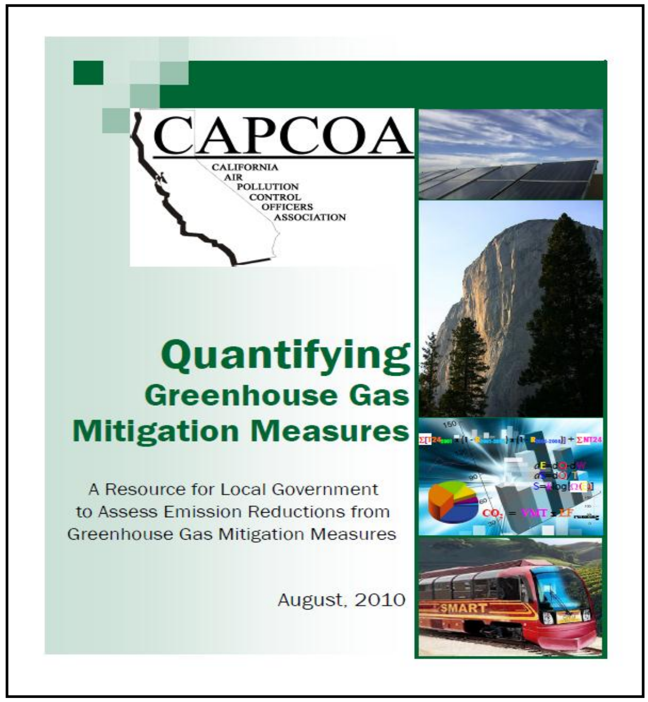
CHAPTER 1. INTRODUCTION

The Bay Area Air Quality Management District's Transportation Demand Management Tool ("TDM tool" or "tool") is an excel-based spreadsheet that streamlines the steps and calculations documented in the California Air Pollution Control Officers Association (CAPCOA) August 2010 report, *Quantifying Greenhouse Gas Mitigation Measures – A Resource for Local Government to Assess Emission Reductions from Greenhouse Gas Mitigation Measures* ("CAPCOA report" or "report"). This user's manual will begin with a brief background on the CAPCOA report to familiarize the reader with the broader concepts and overall goal of the tool. Following will be general instructions for inputting information and guidance on using the tool.



The CAPCOA report is the tool's foundation and the user is presumed to be well familiar with it. Accordingly, this manual will frequently make reference to sections of the report rather than provide detailed instruction or explanation of assumptions in the tool's calculations.

The user is advised to pay careful attention to assumptions and limitations set forth in the CAPCOA report's transportation fact sheets for each of the measures. Once the user understands the quantification context of the measures, this tool can be readily used. Provided below are helpful sections of the report that the user is encouraged to first become acquainted with:

- **Chapter 4: Quantification Approaches.** This chapter discusses the underpinnings of the quantification methods and specifically addresses limitations in the data that was used as well as limitations in applying the measures.
- **Chapter 7: Fact Sheets.** This chapter contains the specific quantification methods behind the tool's calculations and provides greater detail on the measures themselves.
- **Appendix C: Transportation Appendices.** This appendix contains summary information about the measures' calculations, trip adjustment factors, and discussion on induced travel.

The report may be downloaded in its entirety from CAPCOA's website at http://www.capcoa.org

1.1 GOAL AND PURPOSE OF THE TOOL

The Bay Area Air Quality Management District (BAAQMD) sought to identify and develop a tool that would be useful to local planners and support infill project. The primary goal of the tool is to bring reliable quantification of mitigation into a project-level analysis under the California Environmental Quality Act (CEQA). In essence, the tool enables better assessment of measures that a land use development project can implement to reduce project-level VMT, and in turn, help reduce air pollution and greenhouse gas emissions. Many, if not all, of the measures in this tool are already being implemented by local jurisdictions and businesses throughout the Bay Area. However, current practice to gauge their effectiveness may be inaccurate due to data availability, lack of technical expertise, limited resources, or other contributing factors.

The tool is designed to allow for more consistent determinations from project to project of the benefits that TDM categories and individual TDM measures offer. Like the CAPCOA report, the tool's calculations are based on evidence drawn to the extent available. Where possible, Bay Area focused literature and transportation data were used instead of more general data. In addition to providing the findings and formulas of the CAPCOA report in a convenient interactive program, the tool builds upon earlier work by (1) validating the VMT and trip reduction findings in the CAPCOA report in comparison with data from a variety of existing sites within the Bay Area, and (2) recalibrating the tool based upon the results of the validation process. The validation and recalibration processes were undertaken to verify the reliability of the CAPCOA report methodologies and the tool's performance, advance the understanding of TDM quantification, and provide a means for further recalibrating the tool to improve the accuracy of calculation results. This validation and recalibration are also essential for the tool's accepted use within the context of an environmental review pursuant to CEQA. A separate technical memorandum prepared for BAAQMD as part of the tool's development documents these processes and its findings. For more information, see the BAAQMD's Smart Growth website at http://www.baaqmd.gov/Divisions/Planning-and-Research/Smart-Growth.aspx.

Another feature of the tool is that it provides a digestible supplement to the CAPCOA report. Though comprehensive, the report's 500+ pages can be difficult to navigate and the reader may get lost in the technical detail among the various fact sheets.

In summary, the tool provides for the following:

- A simple user interface to select all applicable measures
- A single page to input all required data to perform VMT reduction calculations
- Automation of all necessary calculations described in each of the CAPCOA report's transportation fact sheets (including calculations for combining measures within categories, across categories, and globally)
- A single page output summarizing percentage VMT reduction estimates by each measure as well as for the project as a whole, and
- Capability to make adjustments to underlying assumptions in the tool

1.2 INTENDED AUDIENCE

Planning agencies, consultants, project sponsors, large employers, and others interested in quantifying the VMT reductions expected of measures being implemented may find the tool to be useful. Furthermore, the project-level quantification of TDM effectiveness is essential to reviewing agencies, including local and regional jurisdictions, under CEQA.

1.3 TYPES OF PROJECTS APPROPRIATE FOR THE TOOL

The tool is considered an important extension of the CAPCOA report to assist planning efforts and for evaluating development projects with multifaceted TDM programs and impact mitigation measures. While the primary goal of the tool is to bring reliable TDM quantification into a CEQA project-based analysis, many of the measures are also good examples of the implementation of planning-level policies.

Most types of land use development projects will find the tool to be useful. The majority of TDM measures are applicable to residential, commercial, and mixed-use projects. Even industrial-type projects may find the commute trip reduction measures to be applicable. The project's immediate surroundings, physical characteristics, and its relative "place type" (i.e. urban, compact infill, suburban center, or suburban) warrant careful consideration. As a general rule, the applicability of measures will vary according to the type of project, its location, and combination of measures. For instance, the commute trip reduction measures would not necessarily apply to purely residential types of development; a commercial project would find some of the land use measures more appropriate than others; a mixed-use project could potentially apply any of the tool's measures. The overall effectiveness of TDM measures is also particularly sensitive to a project's defined location because of what is needed to support non-automotive travel: a combination of convenient access to public transit, strong parking policies, and a diverse and dense range of land uses. As reflected in the literature supporting each of the measures, an urban project can expect to see higher VMT reductions when compared to a suburban project. Furthermore, the effectiveness of certain measures, such as the parking measures, may be dependent on other measures being implemented. For example, a project limiting space for parking should take into account the likelihood of people simply looking to adjacent neighborhoods. The project's parking limits should be coupled with a residential parking permitting program to minimize this potential parking "spillover".

Construction-based VMT is not specifically addressed in the tool. Said another way, none of the measures address VMT associated with workers traveling from the office to a construction site or heavy-duty trucks hauling demolition debris for disposal. However, the commute trip reduction measures may apply to a construction company – as a limited example – with offices near transit or if transit subsidies are provided to its employees.

The tool may provide important and useful information for quantifying anticipated effects in broader planning efforts. For example, a city or county could contemplate different policies and objectives under a range of planning scenarios. This could encompass a mixture of land uses, the location of such land uses, proximity to transit, and various other ways policy may influence travel mode choices. Scenario planning in this way can apply the tool in evaluating the effectiveness of strategies under new plans, special planning districts, or redevelopment areas. However, the user is cautioned because the tool's calibration has been based on project-level empirical data. The "land use" measures are specifically intended to apply to projects that have a radius of ½ mile.

The tool may also lend itself towards demonstrating a project's consistency with the goals and objectives of a local plan, regional plan, or other related planning document. This may include general plans and specific plans, a plan for reducing GHG emissions, a regional air quality or regional transportation plan where VMT reductions may be relevant. For example, although much of the work behind developing the Bay Area's Sustainable Communities Strategy (SCS) involves extensive land use and transportation modeling, the project-level quantification provided by this tool may enhance a city's or county's ability to track their contribution towards meeting the region's GHG emission goals.

1.4 GENERAL ASSUMPRTIONS AND RECOMMENDATIONS

This section is intended to make the user aware of general assumptions and caveats embedded in the tool. The following discussions are to brief the user on the types of data inputs, tips on describing project characteristics, and to glean an understanding of key assumptions that are needed in order to appropriately use the tool. This is not intended, however, to be an exhaustive list when using the tool, considering appropriate characterization of project attributes as inputs, or critiquing a VMT output. Further detail is provided in the CAPCOA report and it is again recommended the user reference the fact sheet that pertains to the particular measure or category in question. For convenience, Appendix B of this document provides detail on maximum achievable reductions, or "caps", for different place types (i.e. urban, compact infill, suburban center, or suburban) that are represented in the tool.

In order to safeguard the accuracy and reliability of the tool's results, the user is encouraged to consider the information provided below and to follow the recommendations at all times.

- A transportation demand management measure is defined here as being a way to increase the efficiency of the transportation system or reduce the demand on the transportation system. This may be achieved by developing more efficient travel patterns through encouraging alternative modes of transportation such as walking, bicycling, public transit, and ridesharing.

- Generalized information about the measures was used to develop the quantification methods. The literature supporting the quantification methodology for each measure frames the description and general characteristics for the measure itself. The data were carefully reviewed to ensure they represent the best information available to serve this purpose. The use of generalized information allows the quantification methods to be used across a range of circumstances including variations in geographical location and population density among others.

- The literature supporting each of the CAPCOA report's fact sheets, and thus the tool's measures, varies in what it reports (i.e. reduction in vehicle miles traveled, reduction in vehicle trips, change in mode share, etc.). For each measure, the metric reported in the fact sheets was adjusted to vehicle miles traveled in order to establish a common "language" so that results from different measures would be comparable, and thus, better enable the combining of reduction estimates across different measures and measure categories. This is done by assuming a *one percent* reduction in vehicle trips equals a *one percent* reduction in vehicle miles traveled. Note, neither the CAPCOA report nor the tool is assuming that a reduction in one vehicle trip is equal to a reduction in one vehicle mile traveled.

- The baseline conditions and quantification methods used to develop the tool's measures reflect the overall intent and efforts behind the CAPCOA report. However, the tool generates an output in terms of VMT reduction; it does not provide an emissions reduction estimate. To provide an emissions reduction estimate requires taking into account many factors such as the type of vehicle, travel speeds, and fuels as they all influence the relationship between emissions and transportation. This is beyond the scope of the tool.

- The majority of transportation impact analysis conducted for CEQA documents in California apply trip generation rates provided by the Institute of Transportation Engineers (ITE) in the regularly updated report *Trip Generation*. The ITE report is based on traffic count data collected over four decades at built developments throughout the United States. This data is typically based on single-use developments located in suburban areas with ample free parking and with minimal transit service or other demand management measures in place. As a result, the ITE trip generation rates represent upper bound estimates for an individual land use type. This presents a good basis against which to measure the trip-reducing effects of any one or more of the tool's TDM measures that will be quantified in subsequent tasks.

- Like the CAPCOA report, the tool includes an overarching assumption that trip generation rates are based on an ITE typical suburban development and associated trip lengths. **Should an unmitigated VMT baseline derived from different trip rates or lengths be used, the accuracy of the tool's output is not guaranteed**. For residential land uses in particular, this includes using only single family and multi-family low density land use types in the unmitigated calculations. Any density or other non-suburban effects on trip generation should be considered during the tool calculations to minimize double-counting potential.

- Some measures that reduce trip generation, thereby VMT, below ITE estimates might be considered to be intrinsic parts of the development proposal rather than mitigation. This could include a project's relative location (e.g. being in a downtown area or near a mass transit station), having comparably high density, containing a mix of land uses, and embodying design concepts such as walkability. Like the CAPCOA report and for purposes of this tool, these are not considered a part of the baseline condition. Rather, they are recognized and quantified as project design features. This approach has the following advantages: (1) it creates a consistent basis of analysis for all development projects regardless of location and self-mitigating features already included in the project proposal, and (2) it highlights all elements of a project that reduce trip generation rates and VMT.

- The tool is calibrated based on project-level empirical data. Specifically, the "land use" measures are intended to apply to projects that have a radius of ½ mile. If the project area under review is greater than ½ mile, disaggregated subarea analysis is recommended. The study area should be divided into subareas of radii of ½ mile, with subarea boundaries determined by natural "clusters" of integrated land uses within a common walkshed. VMT generation and reductions for each subarea should be calculated independently and then combined for total project VMT. Conversely, if a project study area is smaller than ½ mile in radius, other land uses within a ½ mile radius of the key destination point in the study area (i.e. train station or employment center) should be included as inputs to the design, density, and diversity calculations.

- The “land use” category VMT percent reduction maxima, or “caps”, are dependent on project location. Selecting the most appropriate location calls for careful consideration because many calculations are dependent on this factor. For example, projects in urban locations can be expected to have a higher land use category VMT reduction compared to a suburban location (more detail can be found beginning at page 59 of the CAPCOA report). It is as equally important to assess a project’s surrounding land use characteristics independently. For example, a project’s immediate surrounding physical environment may better fit the description of a “suburban center” even if the larger city context is suburban in nature. This may also help identify project conditions that should be considered when applying TDM measures.

- When applying the tool, the user should be aware of any unique project characteristics which may cause the tool to over, or under, estimate the reduction in VMT. The transit accessibility measure is a good example. In general, the closer a project is to a major transit hub, the greater percent VMT reductions are predicted. However, this distance will not capture many other relevant factors such as terrain, barrier effects of major arterials and interchanges, perceived personal safety for pedestrians using the walking routes, and type of project. For instance, a hospital may offer a transit subsidy but staff work schedules do not follow the peak hour travel periods. While the facility may be well within a mile of a transit hub, the low frequencies of transit at off-peak hours may mean a lower than estimated transit ridership. Factors such as this should be assessed on a case-by-case basis to properly adjust the predicted VMT reduction to a more accurate estimate. See Appendix A for further discussion on how various default assumptions may be changed.

- A 25% reduction in work-related VMT is assumed equivalent to a 15% reduction in overall project VMT for the purpose of the tool’s defined global maximum. This can be adjusted, however, for projects that generate only work-related VMT. The user should provide evidence (such as a traffic report or employee survey) to support changing this assumption. See Appendix A for further discussion on various default assumptions may be changed.

- Note that “rural” is not an option under the project location choices. Few empirical studies are available to suggest appropriate VMT reduction quantifications for measures implemented in rural areas. Measures likely to have the largest VMT reduction in rural areas include vanpools, telecommuting, or alternative work schedules, and master planned communities (with design and land use diversity to encourage intra-community travel). Neighborhood Electric Vehicle (NEV) networks may also be appropriate for larger scale developments such as Master Planned Communities.

CHAPTER 2. USING THE TDM TOOL

This chapter presents the necessary system operating and installation requirements as well as user input steps for the TDM tool. In addition, this chapter will also describe how to interpret the tool's input requirements and cover the tool's calculated output results.

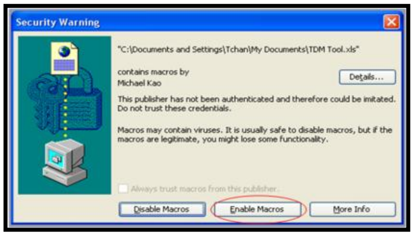
2.1 SYSTEM OPERATING REQUIREMENTS AND PROGRAM INSTALLATION PROCEDURES

The tool uses macros to automate tasks within Excel. Accordingly, the user will need to enable macros in order to run the tool. For convenience, below is a step-by-step process for enabling macros using Excel versions 2003 and 2007.

2.1.1 Enabling Macros

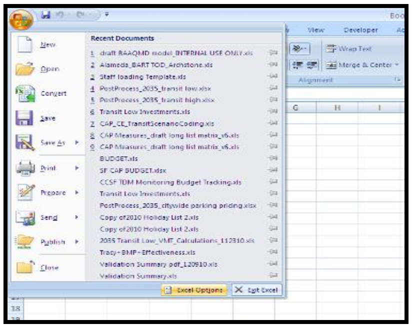
Excel 2003

1. Open the tool in Excel 2003
2. A security warning then will pop up. Click "Enable Macros"

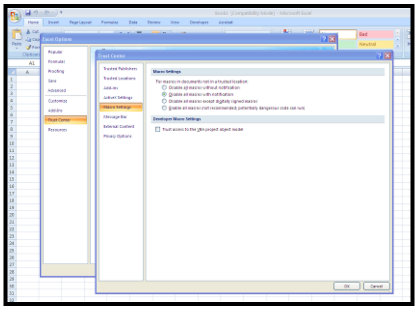


Excel 2007

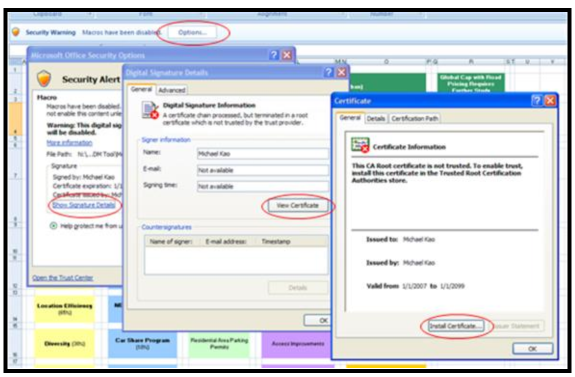
- Open Excel 2007 (while not opening the tool)
- Click the Office icon button at the top left of excel -> Click "Excel Options"



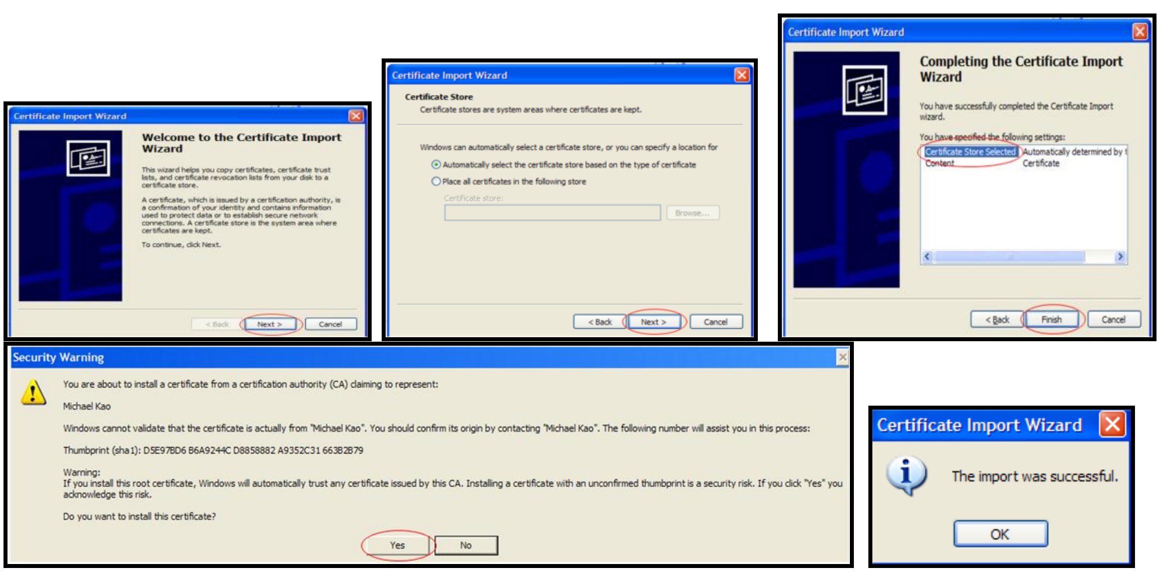
- Click “Trust Center” on left menu bar -> Click “Trust Center Settings…” button -> Click “Macro Settings” on left menu bar -> Select “Disable all macros with notification” -> Click “OK”



- Navigate to the file where the tool is saved
- Open the tool
- Next, click “Options…” next to the security warning at the top -> Click “Show Signature Details” -> Click “View Certificate” -> Click “Install Certificate”



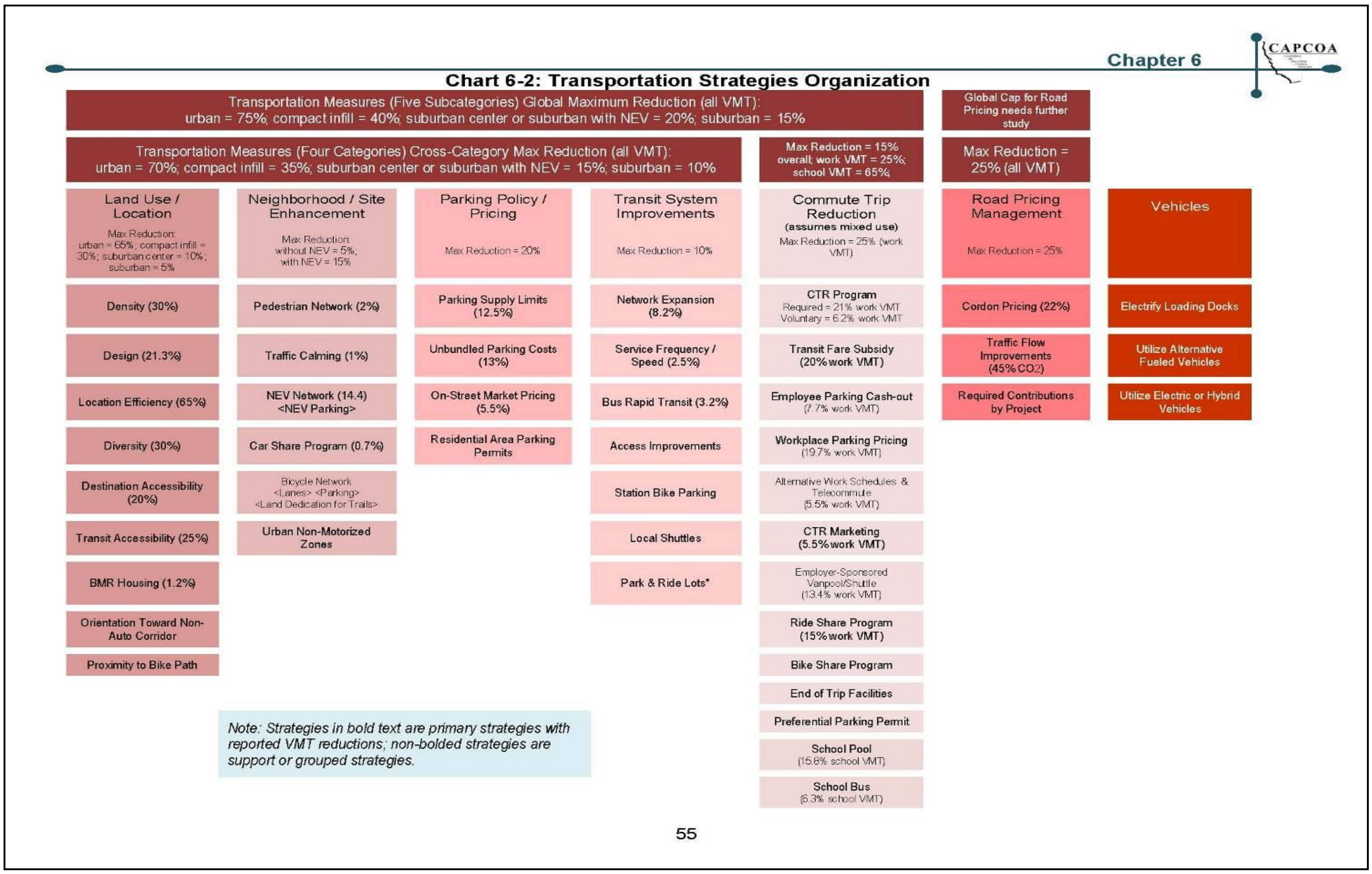
- Follow the steps in the screenshots below:



- Click “OK” until you reach the box below. Select “Trust all documents from this publisher” -> Click “OK”

2.2 TYPES OF MEASURES INCLUDED IN THE TOOL

The measures that are included in the tool were selected on the basis of what they report, the availability of information, and those commonly seen implemented in the Bay Area. **Chart 6-2** from the CAPCOA report, provided below, is a listing of all the TDM measures that have been identified and have a methodology for quantification. Some measures are not incorporated into the tool such as the road pricing and vehicle measures. These types of measures are not included because of the lack of supporting literature or differences in the metric that is reported. Similarly, others are not included because they are more appropriately considered “support measures” such as bus shelters and proximity to bike paths. If these measures were to be implemented alone, they will not be realistically expected to yield an appreciable VMT reduction without other measures in place. These types of measures are more appropriately considered in light of the whole project and its surroundings. For example, having sheltered bus stops may increase the probability of more frequent transit use; the closer homes and businesses are to bike paths the more likely those paths will be used; and residential area parking permits may reduce spillover from neighboring areas where parking supply is limited. In the event of measures being implemented but not represented in the tool, the user is encouraged to consider quantifying them and should refer to a measure’s fact sheet in the CAPCOA report and calculate the measures manually.

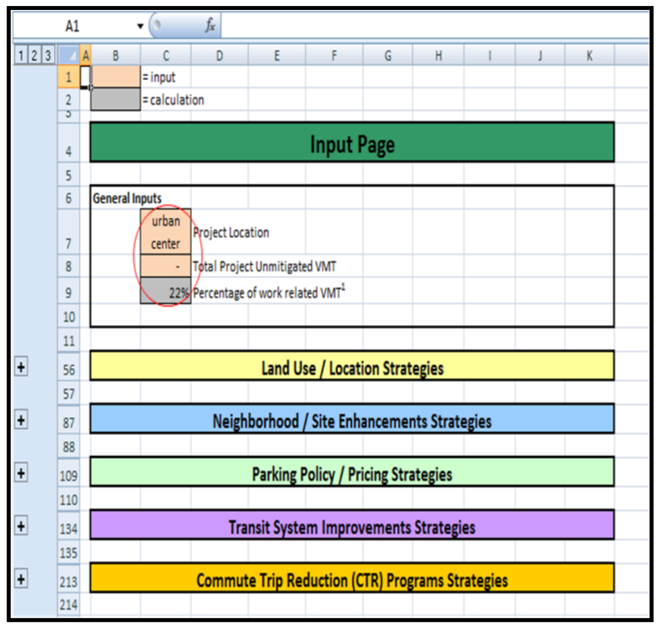


2.3 INPUTS

The **Input Tab** is where the user can provide information to characterize a project using dropdown menus and select individual measures by indicating a simple “yes” or “no” to activate its calculations. If a measure is not activated, its calculations will not be reflected in the tool’s output. Throughout the tool, certain cells will be shaded in pink or gray. Pink shaded cells indicate this box is a user input. Gray shaded cells indicate an embedded equation and these boxes are “locked” so that they cannot be changed. This is done to ensure the reliability and accuracy of the tool’s results.

Project-specific information can be incorporated into the tool’s Input Tab when measures are expanded. Where good quality, project-specific data is available that provides a superior characterization of a particular project, it should be used instead of the more generalized data. See section 2.3.2 “Data Entry” for instruction on inputting project information into the tool.

2.3.1 Input Requirements



The first tab is the user’s input page. As seen in the figure to the right, the first three user inputs are the project location, total project unmitigated VMT, and percentage of work trips. The only input that is required to run the tool is project location.

Project Location

Reduction maxima associated with the “land use” category are dependent on the project’s location. The location-based caps represent the average and maximum reductions that would be likely expected in urban, compact infill, suburban center, and suburban locations. Selecting the most appropriate location calls for careful consideration because many calculations are dependent on this factor. For example, projects in urban locations can be expected to have a higher land use category VMT reduction compared to a suburban location because of higher densities, a relatively diverse mix of land uses, limited parking, with convenient access to transit service. Again, assessing a project’s surrounding land use characteristics independently is as equally important. A project’s immediate surrounding physical environment may better fit the description of a “suburban center” even if the larger city context is suburban in nature. To assist the user in making this determination, the following general guidance should be taken into consideration:

<u>Urban:</u> An urban project is located within the central city and may be characterized by multi-family housing, located near office and retail. This may be further described as:

- Location relative to the regional core: these locations are within, or less than five miles from, the Central Business District
- Ratio or relationship between jobs and housing: jobs-rich (jobs/housing ratio greater than 1.5)

- Density character:
    - Typical building heights in stories: six stories or higher
    - Typical street pattern: grid
    - Typical setbacks: minimal
- Parking supply: constrained on and off street
- Parking prices: high to the highest in the region
- Transit availability: high quality rail service and/or comprehensive bus service at 10 minute headways or less in peak hours

Downtown Oakland and the Nob Hill neighborhood in San Francisco are examples of the typical urban area represented in this category.

<u>Compact Infill:</u> compact infill project is located on an existing site within the central city or inner-ring suburb with high-frequency transit service. This could include projects in community redevelopment areas, reusing abandoned sites, intensification of land use at established transit stations, or converting underutilized or older industrial buildings. This may be further described as:

- Location relative to the regional core: these locations are typically 5 to 15 miles outside a regional Central Business District
- Ratio or relationship between jobs and housing: balanced (jobs/housing ratio ranging from 0.9 to 1.2)
- Density character:
    - Typical building heights in stories: two to four stories
    - Typical street pattern: grid
    - Typical setbacks: 0 to 20 feet
- Parking supply: constrained
- Parking prices: low to moderate
- Transit availability: rail service within two miles, or bus service at 15 minute peak headways or less

Albany is an example of the typical compact infill area represented in this category.

<u>Suburban Center:</u> A project in a suburban center is typically a cluster of multi-use development within dispersed, low-density, automobile dependent land use patterns (a suburb). The center may be an historic downtown of a smaller community that has become surrounded by its region's suburban growth pattern in the latter half of the 20th Century. The suburban center serves the population of the suburb with office, retail and housing which is denser than the surrounding suburb. This may further be described as:

- Location relative to the regional core: these locations are typically 20 miles or more from a regional Central Business District
- Ratio or relationship between jobs and housing: balanced
- Density character:
    - Typical building heights in stories: two stories

    - Typical street pattern: grid
    - Typical setbacks: 0 to 20 feet
- Parking supply: somewhat constrained on street; typically ample off-street
- Parking prices: low (if priced at all)
- Transit availability: bus service at 20-30 minute headways and/or a commuter rail station

Examples of a typical suburban center include downtown San Rafael and downtown San Mateo.

Suburban: A project location in the suburbs is characterized by dispersed, low-density, single-use, automobile dependent land use patterns usually located well outside of the central city (a suburb). This may be further described as:

- Location relative to the regional core: these locations are typically 20 miles or more from a regional Central Business District
- Ratio or relationship between jobs and housing: jobs poor
- Density character:
    - Typical building heights in stories: one to two stories
    - Typical street pattern: curvilinear (cul-de-sac based)
    - Typical setbacks: parking is generally placed between the street and office or retail buildings; large-lot residential is common
- Parking supply: ample, largely surface lot-based
- Parking prices: none
- Transit availability: limited bus service, with peak headways 30 minutes or more

The maximum reduction provided for this category assumes that regardless of the measures implemented, due to the project's distance from transit, density, design, and lack of mixed use destinations will keep the measures effects to a minimum.

Total Project Unmitigated VMT

A project-specific unmitigated VMT, or "baseline", is not required to run the model. However, the tool allows the user to input an unmitigated VMT baseline to which reductions will later be applied. If total unmitigated VMT is entered, the output page will provide both a percent reduction in VMT and a total reduction in VMT. Should a user-defined baseline be entered, the baseline is recommended to reflect a suburban context of land uses, as documented in the Institute of Transportation Engineers' 8th Edition *Trip Generation Manual*. Similar to other analytical tools that utilize TDM measures, this is necessary in order to create a consistent basis from which to measure VMT reductions among the various measures and across categories. Otherwise, there is a high likelihood for double-counting VMT reductions when applying the tool. This also enables a better method of capturing the intrinsic characteristics of a project that reduce VMT, such as densities and transit access, that are not necessarily seen in suburban-style communities. For residential projects, it is important to use trip generation rates for single family detached housing or multi-family residential, as this more accurately represents a typical suburban development. See the CAPCOA report beginning at page 25 and the report's Appendix B beginning on page B-17; *5.9 On-Road Mobile Sources* for further detail.

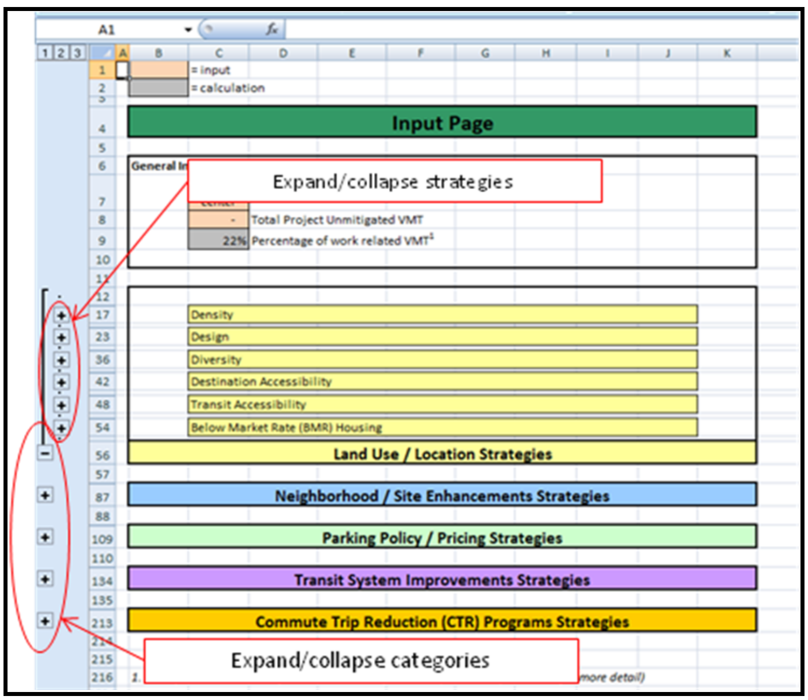
Percent of Work Trips

This optional input has a Bay Area default value with a standard work-related VMT of 21.8 percent. This input will only affect the final percentage VMT reduction if commute-trip reduction measures are utilized. The user should consider adjusting this percentage based on the project characteristics or if project-specific information is available. Under the Assumptions tab, the user can substitute this default value with one more representative of the project site. For example, if the project is an office park with no residential development, the user should replace the number with 100 percent work related VMT.

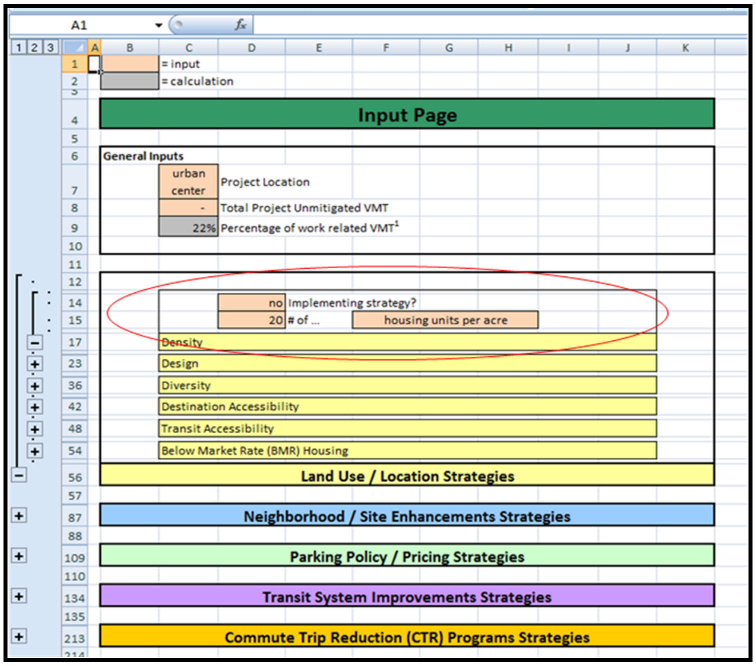
2.3.2 Data Entry

The tool's interface was designed to allow for a maximum degree of ease to the user with minimal need to reference the CAPCOA report fact sheets. The tool's Input Tab contains all available measures, organized by category. To insert project specific information, expand a category and select the measure to calculate. To input project information, select the appropriate measure and the input fields will "drop" the menu to provide an expanded list. Provided below is a step by step process, with illustrations, to input information into the tool.

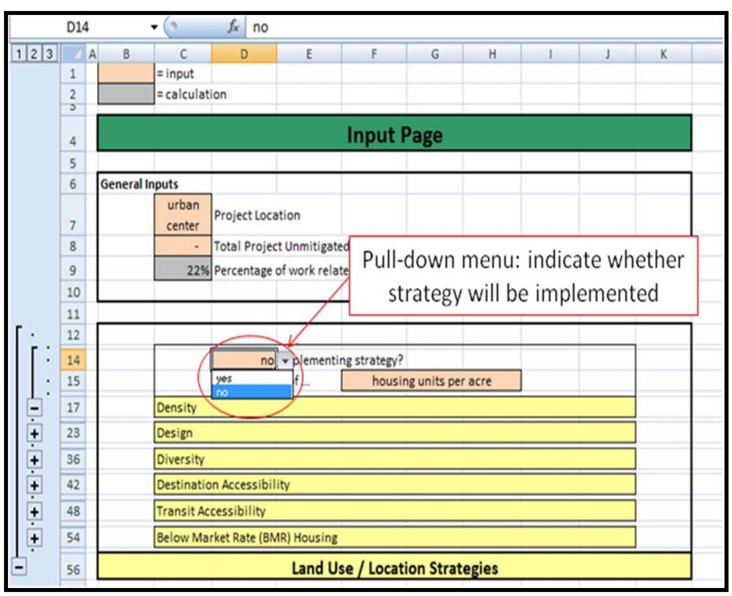
1. Expand each color-coded headings to view a list of the specific measures under the category.



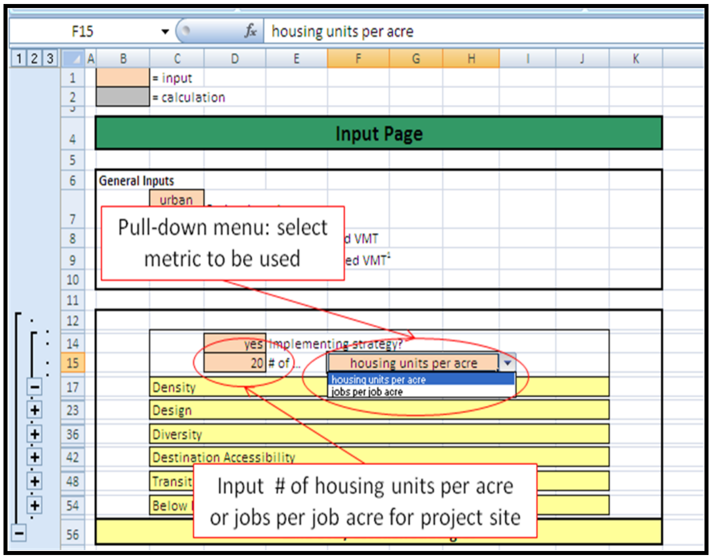
2. Expand each individual measure to see where to provide user inputs.



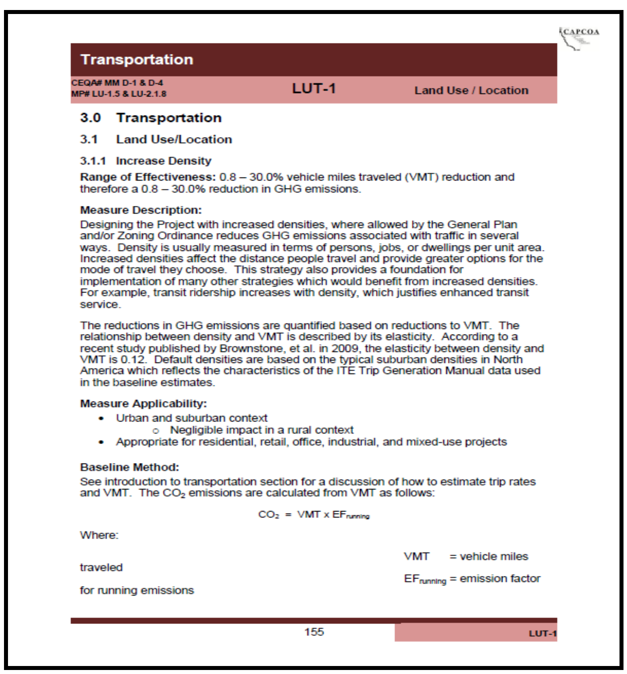
3. Select “yes” or “no” on the pull-down menu to indicate whether the measure will be implemented. Note: it is very important to make sure each measure is properly categorized as “yes” or “no”. Improper categorization will skew resulting VMT reductions. For this reason, it is important to start each new project analysis from the default spreadsheet rather than copying from another project’s spreadsheet. A good way to spot check is by viewing the tool’s output page where reductions attributed to any active measure are easily identified.



4. Provide all additional user information for the individual measure. For example, the density measure requires input for the number of housing units per acre or jobs per job acre for the project site. In addition, the user needs to click the pull-down menu to select which metric will be used.



5. Refer to the individual measure's fact sheet in the CAPCOA report for rules, restrictions and caveats regarding selecting the measure. Again, if there are any questions regarding the required inputs, reference the fact sheet applicable to that measure. For example, the user will reference fact sheet #LUT-1 for more details and information regarding the tool's land use density measure.



CAPCOA

Transportation

CEQA# MM D-1 & D-4
MP# LU-1.5 & LU-2.1.8

LUT-1

Land Use / Location

3.0 Transportation

3.1 Land Use/Location

3.1.1 Increase Density

Range of Effectiveness: 0.8 – 30.0% vehicle miles traveled (VMT) reduction and therefore a 0.8 – 30.0% reduction in GHG emissions.

Measure Description:

Designing the Project with increased densities, where allowed by the General Plan and/or Zoning Ordinance reduces GHG emissions associated with traffic in several ways. Density is usually measured in terms of persons, jobs, or dwellings per unit area. Increased densities affect the distance people travel and provide greater options for the mode of travel they choose. This strategy also provides a foundation for implementation of many other strategies which would benefit from increased densities. For example, transit ridership increases with density, which justifies enhanced transit service.

The reductions in GHG emissions are quantified based on reductions to VMT. The relationship between density and VMT is described by its elasticity. According to a recent study published by Brownstone, et al. in 2009, the elasticity between density and VMT is 0.12. Default densities are based on the typical suburban densities in North America which reflects the characteristics of the ITE Trip Generation Manual data used in the baseline estimates.

Measure Applicability:

- Urban and suburban context
  - Negligible impact in a rural context
- Appropriate for residential, retail, office, industrial, and mixed-use projects

Baseline Method:

See introduction to transportation section for a discussion of how to estimate trip rates and VMT. The CO_2 emissions are calculated from VMT as follows:

$$CO_2 = VMT \times EF_{running}$$

Where:

VMT = vehicle miles traveled

$EF_{running}$ = emission factor for running emissions

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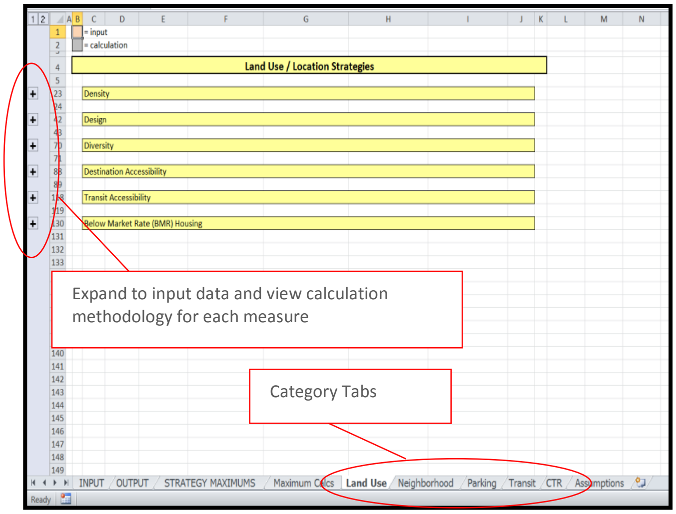
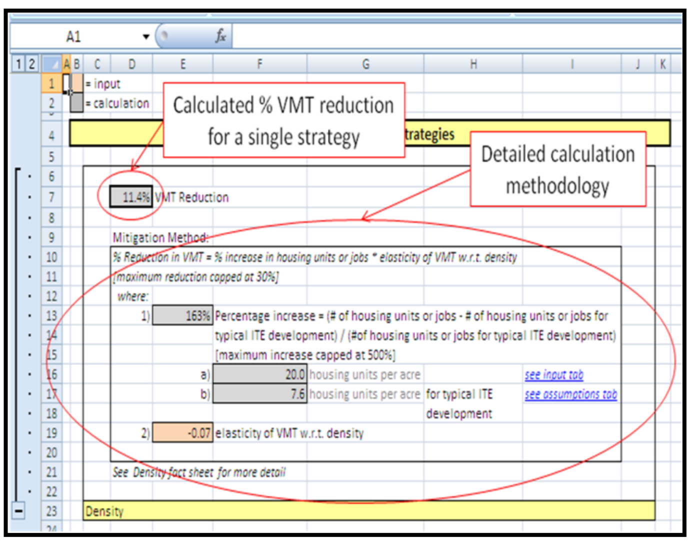
6. Repeat steps #1-5 for all applicable measures.

2.3.3 *Category Tabs*



Understanding the tool's category tabs is an important first step before inputting information. The tool's interface provides a separate tab for each category of measures, including:

- "**Land Use**" tab for Land Use / Location measures
- "**Neighborhood**" tab for Neighborhood / Site Enhancement measures
- "**Parking**" tab for Parking Policy / Pricing measures
- "**Transit**" tab for Transit System Improvements measures
- "**CTR**" tab for Commute Trip Reduction Programs measures



Each category tab elaborates on the calculations needed for an individual measure. For example, under the "Land Use" tab, six land use measures can be expanded to view methodology details and calculations behind each measure. This includes, individual equation(s) that are used, what information in the input tab is being used, a list of other key variables, and the final calculated percent VMT reduction for that particular measure. In the figure to the left, information was inputted into the "density" measure and the percent reduction in VMT is calculated with the equation "% increase in housing units or jobs multiplied by the elasticity of VMT with respect to density". The input (20 housing units per acre) initially entered in the input tab is used to calculate the percent increase in housing units, the elasticity used from supporting literature is -0.07, and the resulting percent VMT reduction is 11.4%. More detail regarding the source of the calculations is documented in the individual measure's fact sheet in the CAPCOA report.

2.3.4 Special Considerations

Parking Measures

Implementing a parking management strategy in one area may have an unintended consequence of impacting the surrounding neighborhood. For example, assume parking meters are installed on all streets in a commercial/retail block with no other parking strategies implemented. Customers will no longer park in the metered spots and will instead “spillover” to the surrounding residential neighborhoods where parking is still unrestricted. To help minimize spillover, parking measures should be implemented in one of two combinations:

(1) Limited (reduced) off-street supply ratios plus residential permit parking and priced on-street parking, or

(2) Unbundled parking plus residential permit parking and priced on-street parking.

Commute Trip Reduction (CTR) Measures

In the course of the validation process, it was found that projects closest to transit reasonably have a higher risk of double counting with commute trip reduction (CTR) measures based on the transit accessibility literature (where all trip reduction credit was attributed to transit proximity). Being less than ¼ mile from transit is probably the greatest motivation to use transit, whereas any additional CTR strategies would likely not provide much incremental benefit. On the other hand, with projects > ½ mile from transit, proximity alone likely will not motivate significant transit use. CTR strategies in these cases will likely have a much larger impact in increasing alternative means of commuting. Therefore, it is recommended:

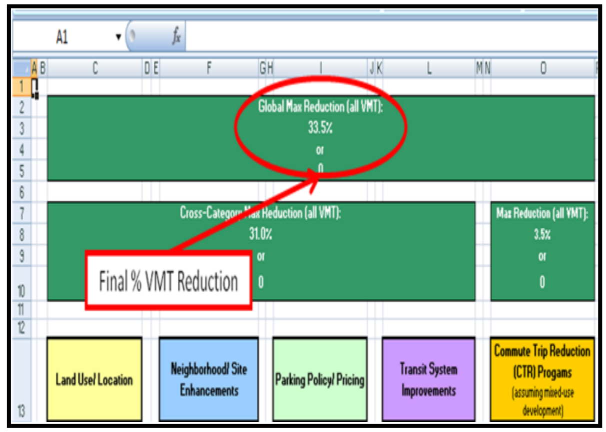
- For projects ≤ ¼ mile from transit: apply the transit accessibility measure but do not apply any other CTR measure (VMT reductions result from close proximity to transit);

- For projects ≥ ¼ mile but ≤ ½ mile from transit: apply the transit accessibility and CTR measures (transit proximity and CTR measures both play a role if office is near transit); and

- For projects ≥ ½ mile from transit: do not apply the transit accessibility measure but do apply CTR measures (when offices are not near transit, VMT reductions result from CTR)

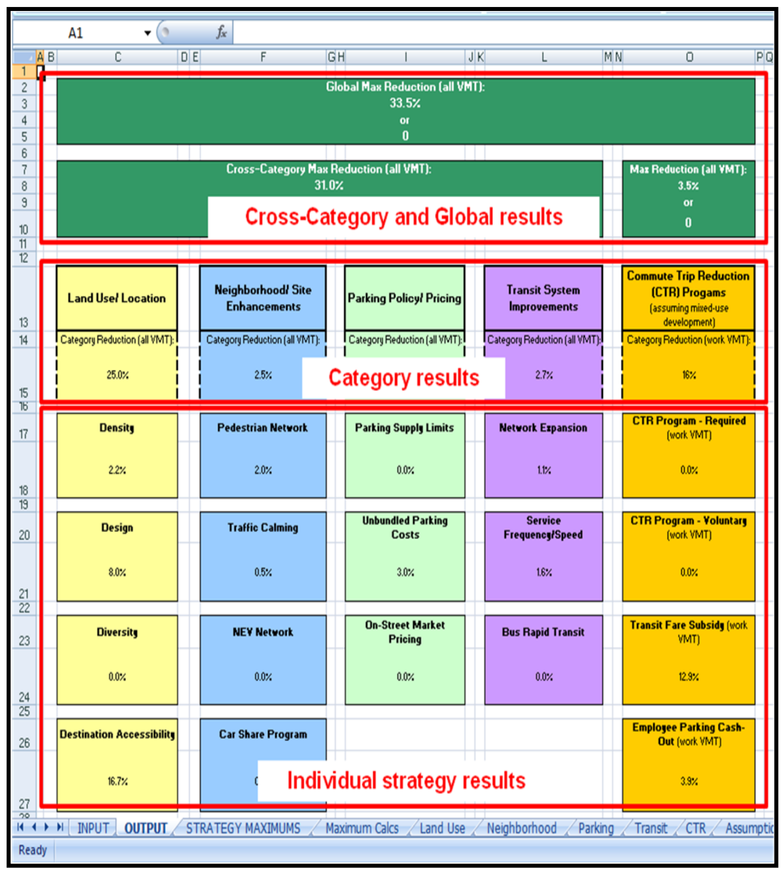
2.4 OUTPUTS

The **Output Tab** provides the results of the VMT reduction calculations. The tool's primary output is provided as the "global maximum reduction" which accounts for all active measures, highlighted in the figure to the right. This tab also provides estimates for the cross-category reduction as well as for individual measures. For each of these outputs a "cap" is in place to minimize double-counting and ensure robust results. This cap is directly tied to the project's location (i.e. urban, compact infill, etc.).



The output tab summarizes the calculated percent VMT reduction in a variety of ways. This is intended to provide greater transparency in the tool's calculations. Descriptions for type of output are provided below. Appendix B provides more technical detail.

- The global max reduction cell provides the overall percent VMT reduction for the project.
- The calculated percent VMT reduction (and total VMT reduction, if baseline unmitigated VMT was provided) for cross-category and globally is shown across the top in the green cells. These cells show the results of the cross-category and global VMT reductions after the cross-category and global maximum limits have been applied.
- The calculated percent VMT reduction by category is shown at the top of each color-coded column, in the dotted cells. These cells show the results of the category VMT reductions after the category maximum limits have been applied.
- The calculated percent VMT reduction by individual measure is shown within a measure's cell with each category and its measures, color-coded for easy reference.



As illustrated in the figure above, the user (or reviewer) is able to quickly identify which measures have been inputted into the tool by simply viewing the output tab. In this example, the following measures were active: three land use/location, two neighborhood/site enhancement, one parking policy/pricing, two transit system improvements, and two commute trip reduction strategies. A reduction attributed to an individual measure is made evident by the percent in the measure's respective box (e.g. the %VMT reduction from the land use/location category under the "density" measure is 2.2%). The category reduction resulting from all land use/location measures is 25% while the cross-category maximum reduction among all categories is 31% (absent commute trip measures because these types of measures only affect a worker's commute VMT). The global max reduction (accounting for commute trip reduction measures) is 33.5%. As a reminder, the tool and manual are both intended to be supplemental to the CAPCOA report. Should questions arise about the tool's output, it is recommended the user review the CAPCOA report for:

- Clarification on the context of each measure that can be found in the fact sheets;
- Assumptions and limitations of each measure's calculations; or
- Required prerequisites or recommended complementary measures

The tool uses quantification methods that were developed to meet the highest standards for accuracy and reliability. Ultimately, however, the user is responsible to confirm and accept any of the tool's outputs. Again, the user is advised to reference the CAPCOA report for background information on concepts associated with the overall transportation categories and individual measures.

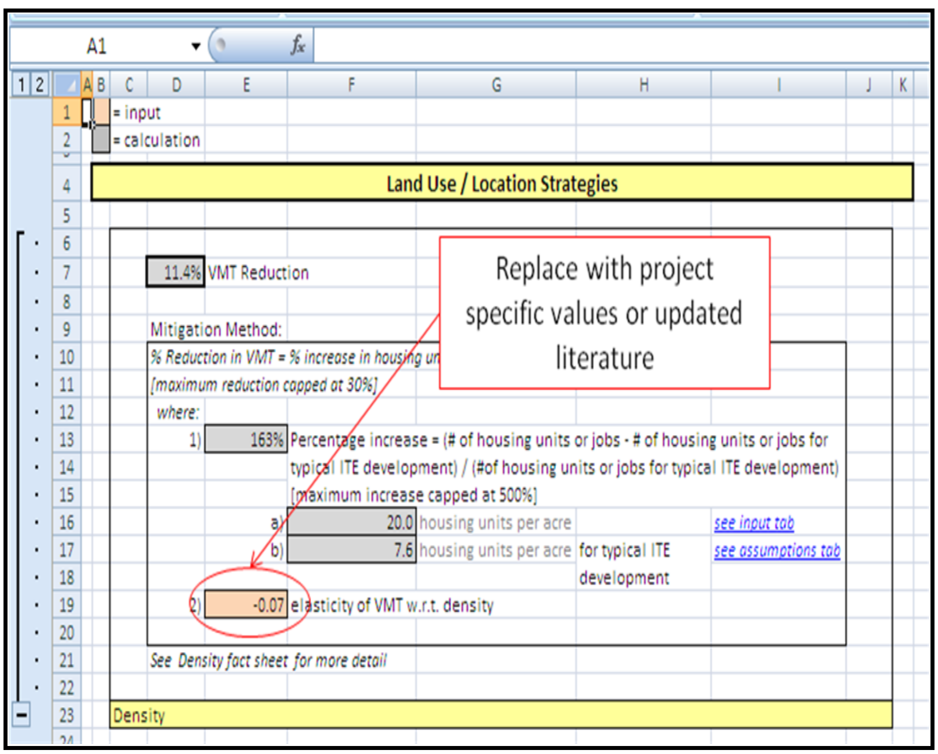
APPENDIX A: ADVANCED USER'S GUIDE

Introduction

This appendix provides guidance for advanced users. This includes identifying opportunities to customize the tool for unique situations where local data on measure effectiveness is available and making changes to the tool's assumptions.

User Updates in the Categories Tab

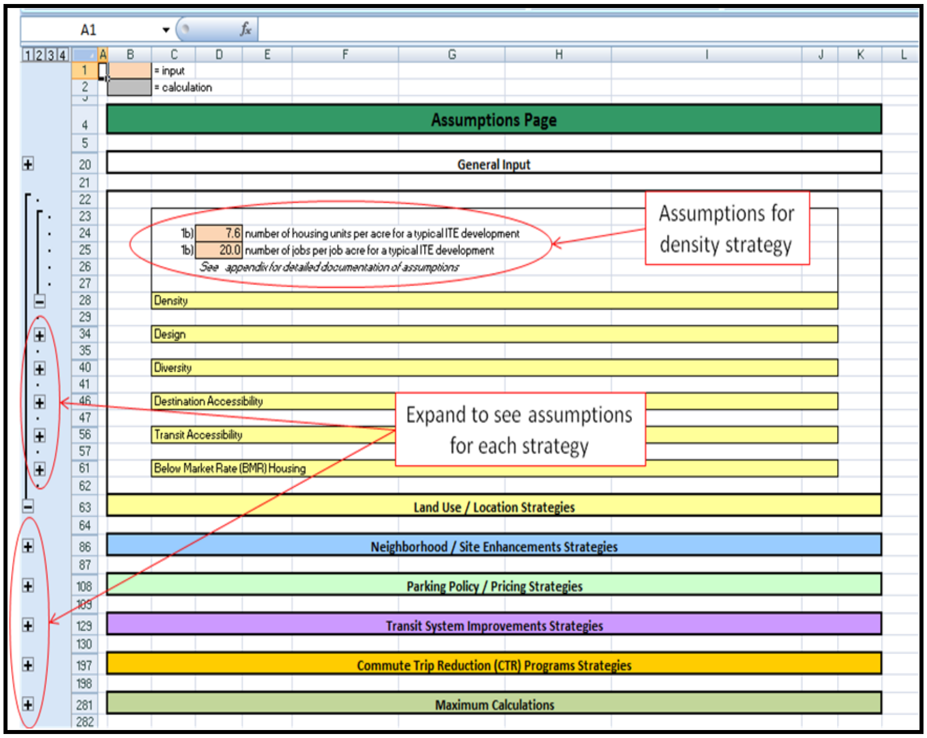
If the user finds more up-to-date or project relevant data, this can be used to replace existing variables in the calculations. For example, if the user finds more comprehensive literature regarding the elasticity of VMT with respect to density, the -0.07 value currently being used, shown in the pink cell, can be overridden.



Assumptions Tabs

Some measures require assumptions within their calculations. For example, under the "density" measure the number of assumed housing units per acre is 7.6 for a typical suburban development, as defined by the ITE Trip Manual.

The Assumptions Tab lists all assumptions made for each measure's calculations. The measures are also grouped by category and the user can expand each category to find assumptions made for each individual measure. More detail regarding the source of the assumptions is documented in Appendix C.1 – Transportation Calculations of the CAPCOA report.

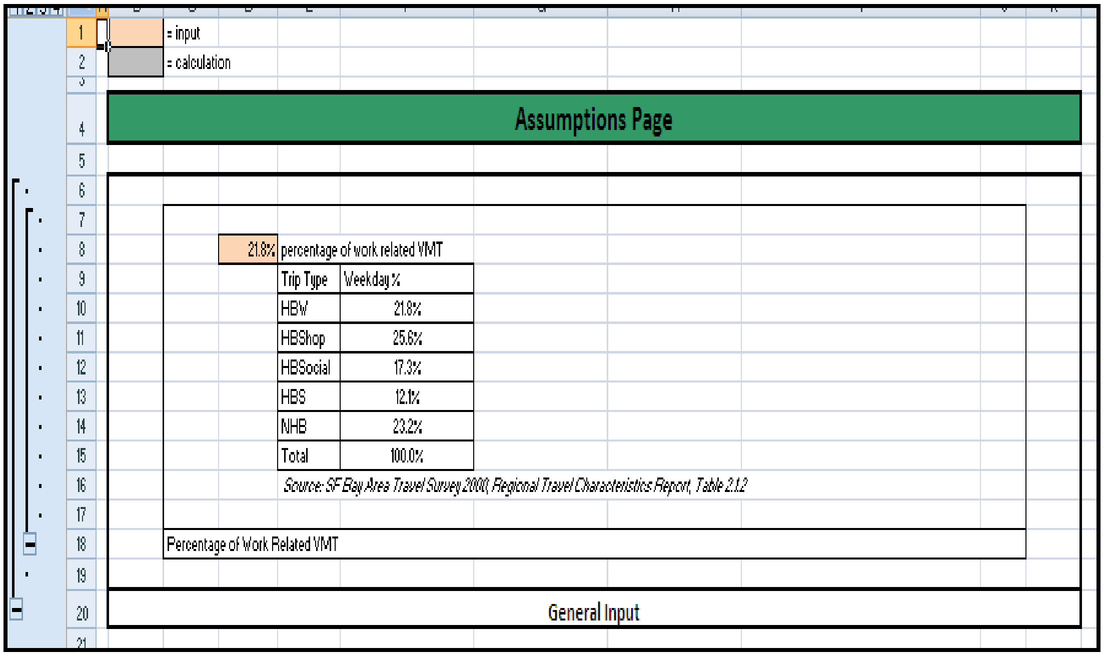


User Updates to the Assumptions Tab

Similar to the calculation variables, if the user finds more up-to-date or project relevant data, such as through additional empirical data collection or new literature, this can be used to replace existing variables (pink cells) in the Assumptions Tab. Changes to the assumptions are not recommended in isolation because the tool has been developed based on a consistent baseline that is inherent in these assumptions.

Percentage Work Related VMT

This optional input has a default value with a standard work-related VMT of 21.8 percent. This input will only affect the final percentage VMT reduction if commute-trip reduction measures are utilized. The user should consider adjusting this percentage based on the project characteristics or if project-specific information is available. Under the Assumptions tab, the user can replace the default standard work related VMT with a value representative of the project site. For example, if the project is an office park with no residential development, the user should instead use 100 percent work related VMT.


= input
= calculation

Assumptions Page

21.8% percentage of work related VMT

Trip Type	Weekday %
HBW	21.8%
HBShop	25.6%
HBSocial	17.3%
HBS	12.1%
NHB	23.2%
Total	100.0%

Source: SF Bay Area Travel Survey 2000, Regional Travel Characteristics Report, Table 2.1.2

Percentage of Work Related VMT

General Input

APPENDIX B: CATEGORY AND CROSS-CATEGORY MAXIMA

Individual Measures

The tool employs a **maximum reduction factor** for individual measures as well as the combination of measures. Providing these maximum "caps" on combinations of measures is essential to minimize double-counting. As noted in the CAPCOA report, when more and more measures are layered onto a project, the benefit of each addition measure can be expected to diminish. If not, some odd results would occur. For example, if there were a series of measures that each, independently, was predicted to reduce VMT by 10%, and if the effect of each measure was independent of the others, then implementing ten measures would reduce all VMT. This begs the question, what would happen with the eleventh? Would the combination reduce 110% of the project's VMT? No. In fact, each successive measure is slightly less effective than predicted when implemented on its own. The BAAQMD's validation process highlights the importance of instituting a maximum cap for each measure, category of measure, and overall VMT reduction. A separate technical document further explains the validation process and steps taken in the tool's recalibration. See the BAAQMD's CEQA website under Tools and Methodology at http://www.baaqmd.gov/Divisions/Planning-and-Research/Smart-Growth.aspx for more information.

Some measures may be more effective when implemented in combination with others. For example, the "density" measure provides a good foundation for implementation of other measures which would benefit from increased densities, such as transit ridership and mixed-use projects. Effectiveness levels for multiple measures within a subcategory (i.e. among the tool's columns) may be multiplied to determine a combined effectiveness level up to the defined maximum amount. This should be done first to measures that are within the same category followed by reductions in others. Since the combination of measures and independence of measures is complicated, the tool employs a multiplication of measure-related reductions within a category unless a project applicant can provide substantial evidence indicating that VMT reductions are independent of one another. This calculation takes the following form:

$$\text{VMT reduction for category} = 1-[(1-A) \times (1-B) \times (1-C)]$$

Where:

A, B and C = Individual reduction percentages for the measure to be combined in a given category.

A global maximum level is also provided for a combination across subcategories. Effectiveness levels for multiple measures across different categories may also be multiplied to determine a combined effectiveness level up to global maximum level. See CAPCOA report, beginning at page 56 for further explanation.

Combination between Categories

The interactions between the various categories of transportation-related measures are complex and sometimes counter-intuitive. As documented in the CAPCOA report, in order to safeguard the accuracy and reliability of the methods, while maintaining their ease of use, maximum reduction values were developed to reflect the highest reduction levels justified by the literature.

Land Use/Location Measures – Maximum Reduction Factors

In the tool, land use measures are capped in terms of VMT reductions based on the empirical evidence for the following location setting types.[1]

- Urban: 65% VMT maximum reduction

  The urban maximum reduction is derived from the average of the percentage difference in per capita VMT versus the California statewide average (assumed analogous to an ITE baseline) for the following locations:

Location	Percent Reduction from Statewide VMT/Capita
Central Berkeley	-48%
San Francisco	-49%
Pacific Heights (SF)	-79%
North Beach (SF)	-82%
Mission District (SF)	-75%
Nob Hill (SF)	-63%
Downtown Oakland	-61%

  The average reflects a range of 48% less VMT/capita (Central Berkeley) to 82% less VMT/capita (North Beach, San Francisco) compared to the statewide average.

- Compact Infill: 30% VMT maximum reduction

  The compact infill maximum reduction is derived from the average of the percentage difference in per capita VMT versus the California statewide average for the following locations:

Location	Percent Reduction from Statewide VMT/Capita
Franklin Park, Hollywood	-22%
Albany	-25%
Fairfax Area, Los Angeles	-29%
Hayward	-42%

[1] As reported for select California locations (noted here) in Holtzclaw, et al. "Location Efficiency: Neighborhood and Socioeconomic Characteristics Determine Auto Ownership and Use – Studies in Chicago, Los Angeles, and San Francisco." *Transportation Planning and Technol*ogy, 2002, Vol. 25, pp. 1–27.

The average reflects a range of 22% less VMT/capita (Franklin Park, Hollywood) to 42% less VMT/capita (Hayward) compared to the statewide average.

- Suburban Center: 10% VMT Maximum Reduction

The suburban center maximum reduction is derived from the average of the percentage difference in per capita VMT versus the California statewide average for the following locations:

Location	Percent Reduction from Statewide VMT/Capita
Sebastopol	0%
San Rafael (Downtown)	-10%
San Mateo	-17%

The average reflects a range of 0% less VMT/capita (Sebastopol) to 17% less VMT/capita (San Mateo) compared to the statewide average.

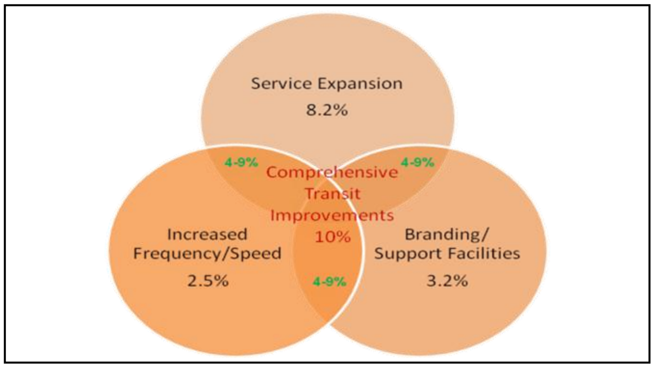
- Suburban: 5% VMT Maximum Reduction

A project location in the suburbs is characterized by dispersed, low-density, single-use, automobile dependent land use patterns, usually outside of the central city (a suburb). TDM measures are expected to have limited efficacy in this context.

Neighborhood/Site Enhancements Measures – Maximum Reduction Factors

The neighborhood/site enhancements category is capped at 15% VMT reduction (with Neighborhood Electric Vehicles (NEVs)) and 5% without NEVs based on empirical evidence (for NEVs) and the multiplied combination of the non-NEV measures.

Combined Categories of the Measures – Maximum Reduction Factors



A **cross-category mmaximum** is provided for any combination of land use, neighborhood enhancements, parking, and transit measures. The total project VMT reduction across these categories should be capped at these levels based on empirical evidence.[2] Caps are provided for the location/development type of the project. VMT reductions may be multiplied across the

[2] As reported by Holtzclaw, et al for the State of California.

four categories up to this maximum. These include:

- Urban: 70% VMT
- Compact Infill: 35%
- Suburban Center (or Suburban with NEV): 15%
- Suburban: 10% (note that projects with this level of reduction must include a diverse land use mix, workforce housing, and project-specific transit; limited empirical evidence is available).

Commuter Trip Reductions (CTR) Measures

The most effective commute trip reduction measures combine “carrots,” “sticks,” and mandatory monitoring (often through a TDM ordinance). “Carrots” provide an incentive which encourages a particular action. Parking cash-out would be considered a “carrot” since the employee receives a monetary incentive for not driving to work, but is not punished for maintaining status quo. “Sticks” establish a penalty for a status quo action. Workplace parking pricing would be considered a “stick” since the employee is now monetarily penalized for driving to work. The 25% maximum for work-related VMT reflects this type of CTR program. TDM measures that include only carrots, only sticks, and/or no monitoring “teeth,” should have a lower total VMT reduction than those with a comprehensive approach. Support measures that should be considered with all commuter trip reductions include guaranteed ride home programs, taxi vouchers, and message boards/marketing materials. A 25% reduction in work-related VMT is assumed equivalent to a 15% reduction in overall project VMT for the purpose of the global maximum below. This can be adjusted for project specific land use mixes.

Two school-related VMT reduction measures are also provided in this category. The maximum reduction for these measures should be 65% of school-related VMT based on the literature.

Transit Measures

The 10% VMT reduction maximum for transit system improvements reflects the combined (multiplied) effect of network expansion and service frequency/speed enhancements. A comprehensive transit improvement would receive this type of reduction.

Parking Measures

The reduction maximum of 20% VMT reflects the combined (multiplied) effect of unbundled parking and priced on-street parking.

Global Maximum Reduction Factor

A **“**global maximum**”** is provided for any combination of land use, neighborhood enhancements, parking, transit, and commute trip reduction measures. Note that this excludes reductions from road-pricing measurements which are discussed separately below. The total project VMT reduction across these categories, which can be combined through multiplication, should be capped at these levels based on empirical evidence.[3] Caps are provided for the location/development type of the project. These include:

- Urban: 75% VMT
- Compact Infill: 40% VMT
- Suburban Center (or Suburban with NEV): 20%
- Suburban: 15% (note that limited empirical evidence is available for this context)

The validation and calibration process conducted during the development of the tool added an additional step in the cross-category combinations. Where a project receives reductions for both CTR and proximity to transit, the combination of these effects are dampened to reduce double counting. The validation and calibration process and this dampening adjustment are described in a separate memorandum. For more information, see the BAAQMD's Smart Growth website at http://www.baaqmd.gov/Divisions/Planning-and-Research/Smart-Growth.aspx for more information.

[3] As reported by Holtzclaw, et al for the State of California. Note that CTR measures must be converted to overall VMT reductions (from work-trip VMT reductions) before being combined with measures in other categories.